

Information Summaries

IS-97/08-DFRC-SP1

Speed Power

Background

One of the most critical characteristics of a new airplane is its range capability, that is, the distance that it can fly before running out of fuel. Range is also one of the most difficult features to predict before flight since it is affected by many aspects of the airplane/engine combination. Some of the things that influence range are very subtle, such as poor seals on cooling doors or small pockets of disturbed air around the engine inlets.

The measurement of range capability for an actual airplane is therefore a critical flight test goal and has led to the development of special instrumentation to measure fuel flow, engine inlet and exit temperatures and pressures, etc. The most useful method for determining the range capability of an airplane is a series of tests to measure the power required and the fuel used during a short segment of completely stabilized flight. These test maneuvers are called "speed powers".



1. Specific Objective of the Test

Determine the power required and rate of fuel consumption for a particular combination of Mach number and altitude.

2. Critical Flight Conditions

There are several conditions that will influence the data collected for a speed power. The important ones are:

- Mach Number
- Atmospheric turbulence
- Atmospheric temperature
- Atmospheric pressure
- Weight
- Configuration (flaps and landing gear position)

Mach number is the most influential parameter in the determination of range for most jet-powered aircraft. The most efficient cruise conditions occur at a high altitude and at a speed which is just below the start of the transonic drag rise.

Since the drag (and thus the thrust required to maintain constant Mach number) will change as the weight of the airplane changes, it is important that the measurements be taken so as to account for the changing weight as fuel is burned during each test. The method is based on the fact that the angle of attack (and thus the drag) of an airplane will become slightly lower as fuel is used since the airplane is becoming lighter and less lift is required to hold it up. To place the airplane at a comparable angle of attack to data taken at a heavier weight, but still retain the same Mach number, the altitude is increased slightly for the lighter weight test point. This method is referred to as flying at constant W/δ (W-over-delta) and requires some preparation ahead of time as well as some in-flight calculations to determine the altitude for each successive test point as the flight progresses. In the

term W-over-delta, $\frac{W}{\delta}$,

$$\delta = \frac{p}{p_0}$$

p_0 = standard day, sea level pressure ,

and

p = ambient pressure (at altitude) .

3. Required Instrumentation

The parameters usually measured and recorded during speed powers are shown in Table (1-1). The engine instruments shown are representative but not complete. They will vary markedly depending on the type of engine. The engine instrumentation will be used to correct the power and fuel flow measurements to standard day pressures and temperatures by applying corrections for engine thrust.

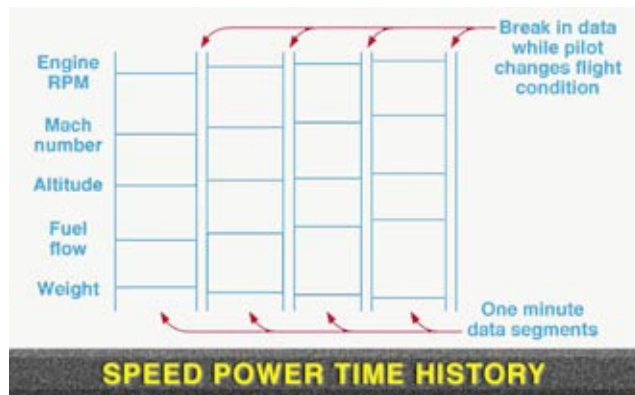
A continuous time history of these parameters is desirable but not essential for these tests.

4. Starting Trim Point

The flight test engineer will establish a table of altitudes (which are specified as W-over-delta's), and Mach numbers where speed powers are to be performed. These test points will be grouped around the Mach number and altitude that are expected to produce the best range for the airplane. A typical sample table of flight conditions for speed powers is shown in Table (1-2).

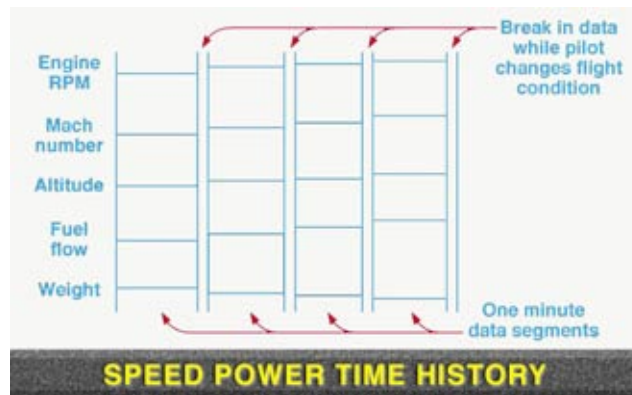
5. Description of a Speed Power

A speed power test point is actually nothing more than a very carefully performed "trim shot". The pilot may spend several minutes in order to achieve the necessary conditions of absolutely stabilized engine power, Mach number and altitude. When the pilot is satisfied that the airplane is stabilized, the data recorder will be turned on and the stable condition recorded for one minute. At the completion of each test point, the amount of fuel remaining in the aircraft will be calculated by the test engineer, and the pilot will be advised of the proper altitude for the next test point (at constant W-over-delta). The pilot will then climb slightly to the new altitude and restabilize the aircraft at the next test Mach number.



6. Measures of Success

A sample speed power is shown.



A successful series of speed powers will meet the following test criteria:

- All instrumented parameters recorded properly.
- Engine thrust, fuel flow, Mach number, and altitude were all stabilized during the one minute recorded test point.
- Post-flight calculations of W-over-delta are consistent for each successive test point.

The fuel flow measurements at each stabilized point are combined with the true speed calculations to produce the specific range parameter, NAMP, "nautical-air-miles-per-pound" (of fuel used).

$$\text{NAMP} = \frac{Vt\delta}{W}$$

The specific range factor is plotted vs Mach number for each value of W/delta (which corresponds to a single altitude for a constant weight). The maximum values of the specific range factor, combined with the corresponding Mach numbers, identify the range capabilities of the airplane at different altitudes.

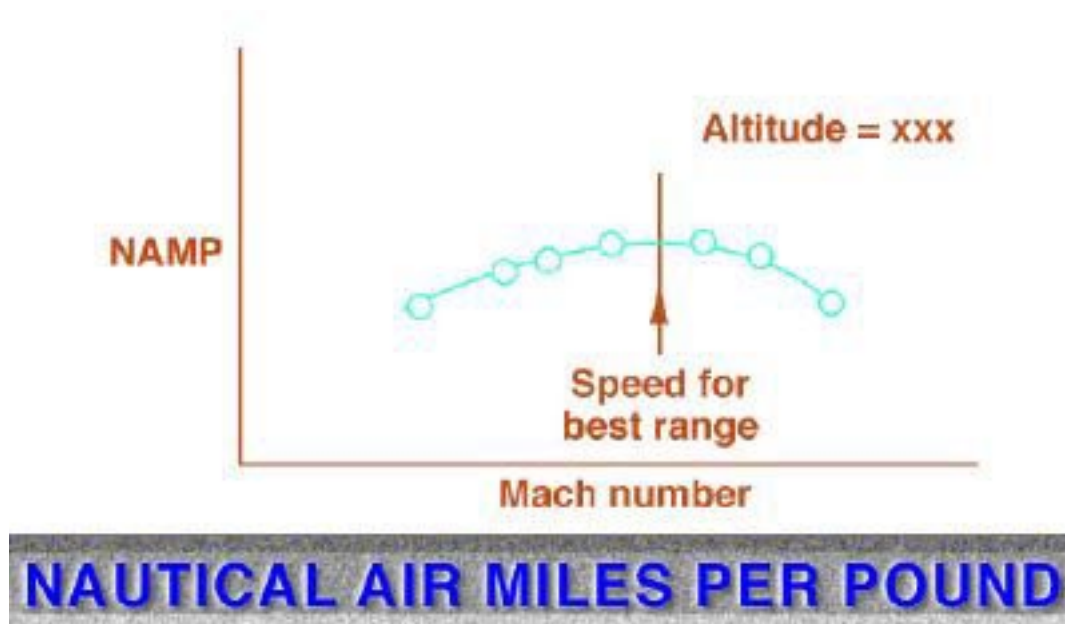


Table 1-1

Listing of Instrumentation Parameters

Parameter	Used For
Airspeed	Compute Mach and dyn. pres.
Pressure Altitude	
Outside Air Temperature	
Altitude	Compute W/delta
Engine RPM	Compute power req'd and thrust corrections to standard day conditions
Engine tailpipe pres. & temp.	
Engine inlet pres. & temp.	
Total fuel flow	Compute weight and NAMP

Table 1-1

Table of Speed Power Conditions

Config.	Approx. Alt.	W/ delta	Stabilized Mach number
CLEAN	10000	72700	.55, .6, .65, .7, .75, .8
	20000	108800	.6, .65, .7, .75, .8, .85
	30000	168350	.65, .7, .75, .8, .85, .9
	35000	212450	.7, .75, .8, .83, .86, .9
	45000	343550	.7, .75, .8, .83, .86, .9
GEAR, FLAPS	5000	60090	140, 150, 160, 170, 180 (Knts)